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ABSTRACT

A description is given of a 3-year research and development project designed to address the fundamental problems of preparing elementary teachers to teach mathematics for understanding. The use of a new technology is proposed. Hypermedia combines elements of multimedia environments for learning and teaching with a recent development in computer software called "hypertext," a representation of multiple and flexible links between discrete pieces of data that allows users to navigate along multiple paths through a network of chunks of information and to build and store their own links. A hypermedia tool can make it possible to access and link video representations of a year's worth of teaching and learning in two mathematics classrooms from teachers' and students' perspectives. It will include video and textual representations of teachers' thinking about both the mathematical content and the pedagogical decisions involved in their work, graphic and textual representations produced by students of their mathematical reasoning processes, and video and textual annotations which analyze lessons from the perspective of relevant academic disciplines. Hypermedia can give teacher education students an experience that is close to observing good mathematics lessons in real classrooms and then give them the opportunity to analyze those lessons with the teacher who taught them. (JD)

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NCRTE

National
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Issue Paper 90-5

USING HYPERMEDIA TECHNOLOGY TO SUPPORT A NEW PEDAGOGY OF TEACHER EDUCATION

Magdalene Lampert and Deborah Loewenberg Ball

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Abstract

The authors are currently engaged in a three-year research and development project designed to address the fundamental problems of preparing elementary teachers to teach mathematics for understanding. The primary funding for this project comes from the National Science Foundation. Based on an analysis of research on teaching, teacher thinking and teacher education, the authors argue that new technologies have the potential to contribute substantially to the improvement of teacher preparation programs.

USING HYPERMEDIA TECHNOLOGY TO SUPPORT A NEW PEDAGOGY OF TEACHER EDUCATION

Magdalene Lampert and Deborah Loewenberg Ball[1]

Defining the Problem

When prospective elementary school teachers enter formal teacher education, they bring images of and assumptions about mathematics teaching and learning derived from their own experiences as students (Ball, 1988a). Neither field experiences in ordinary classrooms nor the conventional academic model of methods and foundations courses has worked very well to alter these images--to give novices knowledge that would help them teach mathematics in ways that differ from typical practice. When alternative ideas about mathematics teaching are offered to prospective teachers in conventional academic formats, they simply do not make much impact on teaching practice. Once teachers find their way into classrooms, they dismiss these ideas as "theoretical" and "unrealistic." And this dismissal is justified--for they have never seen how such ideas might look if they were enacted in the context of ordinary classrooms.

Our aim is to address this problem by developing a new pedagogy of teacher education that represents a major change in the content, the discourse, and the setting of conventional teacher preparation programs. To do this, we will capitalize on recent technological innovations that make it easier to represent the complexity of the work a teacher does in conducting classroom lessons and integrate these representations with theoretical perspectives on mathematics education. The representations of teaching and learning that we seek to produce will be designed to challenge prospective teachers' images of what is possible and practical in elementary classrooms by involving them in the examination of lessons in which teachers and students are engaged in authentic mathematical activity in a school setting.[2] We also want to challenge prospective teachers' ideas about

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[1]Magdalene Lampert, associate professor of teacher education at Michigan State University, and Deborah Loewenberg Ball, assistant professor of teacher education at MSU, are senior researchers with the National Center for Research on Teacher Education. The work described in this paper is funded by National Science Foundation Grant #TPE 8954724. The authors would like to acknowledge the contributions of Mark Rosenberg to their thinking about the relationship between new technologies and the investigation of teaching and learning.

[2]The two classrooms on which we are focusing are classrooms in which the teachers (the authors) have strong backgrounds and interests in the discipline of mathematics and its relationship to the teaching of mathematics. These interests are evident in their research on mathematics teaching and learning and on learning to teach mathematics. Lampert has published several descriptions and analyses of her teaching (Lampert 1985b, 1986a, 1986b, 1988a, 1988b, 1989b, in press-a, in press-b), which are often referred to by researchers and reformers as examples of exemplary practice (Brown, Collins, and Duguid, 1989; Dossey, Mullis, Lindquist, and Chambers, 1987; Driscoll, 1988; Greeno, 1989a; Resnick, in press; Zarinnia, Lamon, and Romberg, 1987). An analysis of the teaching described in Lampert's publications reveals that her lessons include instances of the sorts of mathematical activities that are considered desirable in the reform documents, e.g., the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards* (1989a) and the National Research Council's *Everybody Counts* (1989)--indeed, the latter document refers directly to her work. Ball's work has focused on the role of subject matter knowledge in teaching mathematics (Ball, 1989, in press-b), on prospective teachers' understandings of

what kind of knowledge is useful in teaching and how it might be acquired.

Why a New Pedagogy for Teacher Education?

Learning to teach mathematics for understanding is learning in and about an ill-structured domain. Although it clearly demands substantial knowledge of mathematics as well as considerable understanding of children's learning and of classrooms, knowledge for teaching is more than the compilation of discrete bits of the "right" propositional knowledge. Like other kinds of complex understandings, expert teachers' knowledge and their capacities for using it are situated in the particular contexts of their practice (cf. Brown, Collins, and Duguid, 1989; Dreyfus and Dreyfus, 1987; Perkins and Solomon, 1989; Schon, 1983). And teaching entails weaving together different, sometimes competing, ideas and goals (Bolster, 1983; Buchmann, 1987; Clark and Peterson, 1986; Lampert, 1985a). Conventional forms of teacher education have not taken account of these characteristics of teacher knowledge and teacher thinking (Clark and Lampert, 1986; Shulman, 1986, 1987).

The pedagogy of teacher education as it is now structured is based on a knowledge delivery system that does not take account of what we know about how people learn about ill-structured domains, even though research on teacher thinking and teaching practice has argued that professional knowledge in teaching is indeed "ill-structured." (See Greeno, 1990; and Spiro, Vispoel, Schmitz, Samarapungavan, and Boerger, 1987 for a definition of knowledge in ill-structured domains; see Clark and Lampert, 1986; Clark and Peterson, 1986; and Lampert, 1985a for a review of the research on teachers' knowledge use in practice.) Traditional teacher education draws on theory and research that necessarily reduce the complexity of the learning process in order to focus on its regularities. Teacher educators typically interpret that research and present prospective teachers with "methods" based on synoptic views of learning and teaching. Novices are then expected to apply this knowledge to the particular contexts of practice in which they will find themselves.

The teacher education pedagogy that we hope to support with hypermedia--in contrast to more conventional systems--will enable prospective teachers to learn about teaching mathematics for understanding by directly exploring the terrain of teaching and learning in two classrooms over the course of a whole school year. Given access to this set of information, prospective teachers should be able to form their own hypotheses about teaching and learning and to test those hypotheses against a wealth of data from the two

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mathematics (Ball, 1988a, 1990a, 1990b), and on the process of learning to teach mathematics (Ball, 1988b, in press-b). In introductory education and mathematics methods courses, teacher education students have had the opportunity to observe and participate in her third-graders' mathematics learning, thus instantiating and extending the experiences and ideas of on-campus course meetings (Ball, in press-a). The third-grade mathematics class offers a substantial challenge to prospective teachers' ideas about teaching and learning, as well as about learners (see, for example, McDiarmid, 1989). Ball is also the lead author for the teaching section of the National Council of Teachers of Mathematics *Draft Professional Standards for the Teaching of Mathematics* (1989b).

classrooms. With access to analyses of this teaching and learning prepared by the teachers and other scholars, they will also be able to compare their hypotheses and ways of thinking with the thinking of both highly regarded practitioners and academic commentators on teaching and learning (e.g., psychologists, sociologists, anthropologists, mathematicians). The technology is new, but the problem and ideas about how to solve it have been around for a long time. The approach we are developing begins with the examination of mathematical ideas and teaching strategies set in the messy context of real classrooms. This approach to teaching about teaching turns the conventional pedagogy of teacher education on its head. With the tools we are developing, prospective teachers will learn new ways of thinking about the teaching and learning of mathematics as well as new ways to learn about practice *from* practice. By changing the ways in which knowledge about teaching and learning is produced and delivered, we hope to challenge novices to formulate ideas about good practice founded on the interplay of students' and teachers' confusion and enlightenment, boredom and engagement, communication and miscommunication.

Our belief in the efficiency of this approach to teacher education is based on an analysis of thinking as knowledge use in practice. Becoming a teacher involves both learning *what teachers know* (in the form of propositions and case knowledge) and learning *how teachers think* (Feiman-Nemser and Buchmann, 1985). In the terms of this distinction, teacher thinking might be conceived as *knowing how to use knowledge*--of children, of mathematics, and of the social setting--in the context of practice. Reasoning pedagogically involves weighing multiple and sometimes competing concerns, while attending to the subject matter, the learners, and the context, and coming up with defensible courses of action in situ. Recent work in psychology (e.g., Perkins and Solomon, 1989) suggests that knowledge about problem solving acquired in an academic setting does not easily transfer to nonacademic settings where similar problems need to be solved. Ideas about the situated nature of cognition (Brown, Collins, and Duguid, 1989) suggest that propositional, or "school" knowledge is often not necessarily accessible to people in situations where such knowledge could have been usable and useful (cf. Lave, 1988; Scribner, 1984). This is due, at least in part, to a lack of attention to how the situation in which a problem solver thinks provides tools and how those tools shape the kind of thinking one is able to do (Clancey, in press; Cole and Griffin, 1980; Greeno, 1989a, 1989b; Pea, 1988; Suchman, 1987; Winograd and Flores, 1986).

Conventional teacher education presents propositional knowledge about teaching in the form of "school knowledge." Substantial research shows that this knowledge often does not "transfer" to the classroom setting in which teacher candidates are supposed to "apply" what they are learning (e.g., Feiman-Nemser and Buchmann, 1985). The view of cognition as situated in contexts of practice underscores the argument that simply knowing how experts structure their thinking about a problem tells us little about how they use knowledge in

practice (Clark and Lampert, 1986; Floden and Klinzing; Lampert and Clark, 1990). But more importantly for teacher education, it cautions us to pay attention to how experts *acquire and learn to use* what they know.

In a recent paper, Greeno (1990) has constructed a metaphor for learning to become an expert that seems relevant here. He envisions the domain of knowledge that belongs to experts in a field as an environment in which there is located a collection of resources for knowing, understanding, and reasoning in the domain. Knowing, in this image, means knowing what resources are available in the environment *and being able to find them when you need them*. One needs to be able to "get around" in the territory, as well as having a sense of where there is to go.[3] Propositional knowledge derived from research might be thought of as one kind of resource in a domain, but there are many others, inside and outside of the mind of the individual problem solver, to be taken advantage of.

We might see the conventional pedagogy of teacher education (in the terms of Greeno's metaphor) as giving novices maps of the place where they are expecting to work (based on the findings of conventional research) and then testing their ability to *reproduce the maps*. When they actually arrive in the work situation, there are few guideposts that would enable them to use the maps they have learned to help them find their way around. So they invent new maps, disconnected from the ones they acquired in their courses. There is no opportunity in conventional teacher preparation for learners to map the connections between analyses of good practice and the realities of life in classrooms; thus these two aspects of teacher preparation remain disconnected. It seems worth examining the potential of hypermedia to enable students *at least* to connect the territory of teaching and learning theory to the practice of teaching and *ideally* to support the learners' construction of maps that are informed both by the realities of practice and by the perspectives of others reflecting on practice using the tools of academic discourse.

What Is Hypermedia and Why Use It to Support Teacher Education?

Shulman (1986) distinguishes among three kinds of knowledge needed in teaching: *propositional knowledge*, or the sort that is conventionally delivered in academic settings to be "applied" in practice; *case knowledge*, which has the capacity, by virtue of its attention to vivid detail, to make the propositions it illustrates more memorable; and *strategic knowledge*, which is knowledge as it is used in actual situations of practice. It is this third kind of knowledge we wish to represent to prospective teachers. To quote Shulman and underscore the need for a new pedagogy of teacher education:

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[3]A similar metaphor for expert cognition has been developed by Spiro et al. (1987), following the work of Wittgenstein (1953), to characterize the acquisition of knowledge in "ill-structured disciplines."

> Both propositions and cases share the burden of unilaterality, the deficiency of turning the reader or user toward a single, particular rule or practical way of seeing. Strategic knowledge comes into play as the teacher confronts particular situations or problems, whether theoretical, practical, or moral, where principles collide and no simple solution is possible. Strategic knowledge is developed when the lessons of single principles contradict one another, or the precedents of particular cases are incompatible. (p. 12)

Shulman goes on to argue that a pedagogy for teacher education needs to be developed using methods of instruction which "involve the careful confrontation of principles with cases, of general rules with concrete documented events--a dialectic of the general with the particular in which the limits of the former and the boundaries of the latter are explored" (p. 13). It is precisely this sort of exploration of the theories and practices of mathematics teaching and learning which hypermedia tools can make possible.

Hypermedia is a new concept in educational technology. It combines elements of multimedia environments for learning and teaching with a recent development in computer software called "hypertext" (Ambron and Hooper, 1988; Jones, 1990; Richards, Chignell, and Lacy, 1990; Wilson and Tally, 1990). Hypertext grew out of a system called "memex" imagined by Vannevar Bush in the 1940s. Bush (1945/1988) foresaw the possibility of building electronic linking tools, based on ideas about how people connect ideas in flexible networks, to enable scientists to cope with the "information explosion" occurring in many fields. Hypertext is a representation of multiple and flexible links between discrete pieces of data which allows users to navigate along multiple paths through a network of chunks of information and to build and store their own links. When the data to be linked include video, audio, and graphic as well as textual information, the representation is called hypermedia.

We are currently engaged in a research and development project to produce a hypermedia tool for use in educating teachers which will make it possible to access and link video representations of a year's worth of teaching and learning in two mathematics classrooms from teachers' and students' perspectives, video and textual representations of teachers' thinking about both the mathematical content and the pedagogical decisions involved in their work, graphic and textual representations produced by students of their mathematical reasoning processes, and video and textual annotations which analyze lessons from the perspective of relevant academic disciplines. Designing an integrated system of hardware and software that will provide teacher candidates educative access to this mass of qualitative data about new kinds of teaching and learning is the major challenge we face in using new technologies to support a new pedagogy of teacher education.

A hypermedia environment solidly based in research and theory and rich in information about particular instances of teaching and learning can give teacher education

students an experience that is close to observing good mathematics lessons in real classrooms and then give them the opportunity to analyze those lessons with the teacher who taught them. Additionally, users would be able to analyze what they saw together with other people who have various theoretical perspectives on teaching--such as the people whose work they typically read in teacher education courses. In order to make such experiences possible, we will experiment with integrated computer workstations which bring together hardware and software that have the capacity to catalogue and relate elements of information drawn from video, audio, graphic, and textual sources.

Hypermedia technologies promote access to massive amounts of data in their original formats, preserving their ecological validity and contextual richness, while also allowing for condensation for interpretive analysis. They have the capacity to provide a richer experience than *apprenticing* because they enable the user both to explore teaching and learning in real time and relate real time events to one another in structures that will support the appreciation and development of a teacher's strategic knowledge. In contrast to a *simulation*, software that makes multiple perspectives on a real teaching and learning situation available to users can be designed to highlight aspects of a teaching and learning situation without closing off the learner's access to other elements which define its complexity.

What we envision is the use of learning modules in teacher education settings that will be built around videotaped lessons taught by the authors,[4] in which teacher educators will be able to present to their students a replay of a real time lesson and then conduct an analysis of that lesson in a seminar discussion format. Using this technology, they will be able to access incidents in the lesson for consideration quickly and in direct response to student's concerns and inquiries. The lesson would be treated in a manner analogous to a piece of literature or an historical event to be understood from a variety of perspectives (see Yankelovich, Smith, Garrett, and Meyerowitz, 1987). The teacher educator and the prospective teacher would be engaged with the authors of the system in active reflection and research on mathematics teaching and learning (see Lampert and Ball, in preparation). By utilizing the system we will design, a teacher educator would be able to organize a presentation ahead of time and then by clicking on buttons display and/or play supporting material (video, audio, graphics, and text) for the lecture/talk. Also, because of the flexibility of the system it would be easy for the presenter to link other ideas and examples or pursue questions that come out of the presentation. Hypermedia systems have the

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[4]Although we draw on teaching which is exemplary, we teach in ordinary situations. We are not teaching "one-shot" made-for-television demonstration lessons. We work in a public school with a diverse population, and we are responsible for mathematics instruction in the classrooms in which we work across the entire year. We differ from full-time teachers in that we are also engaged in the process of studying the practices of teaching and learning mathematics and representing these processes in various media to prospective and practicing teachers, researchers, and the general public.

capacity to save the new paths and links so the presenter's knowledge base is expanded and active learning and reorganization of the presenter's own knowledge base is supported.

In the hands of a user who seeks to learn about teaching, the system would enable and encourage exploration and investigation. It would thus support quite a different epistemology than that already embedded in the current knowledge delivery system in teacher education, which has researchers asking interesting questions and collecting data to support answers to those questions while teachers wait for the knowledge they are supposed to "apply" to the problems of practice. In the system we are designing, teacher education students will have the capacity to do research on their own questions about how teaching and learning proceed in classrooms where a different kind of mathematics is being taught. They will have access to tools which enable them to move through various kinds of data (audio, video, written transcripts, voice/written annotated notes by the instructor or other students, and preplanned tours through the data), to construct their own interpretations (which would then be added to the existing annotations so that other students could use them as well), and to present and defend them.

During this process, they would learn to revise and review their original thinking based on new information and perspectives of others. Since hypermedia can be designed to associate and relate information in a variety of formats without respect to proximity or standardized coding, it can provide for multiple paths through the same data. It thereby supports a technology for learning that augments the natural cognitive processing learners bring to a situation and supports the development of reflective conversations among learners as they construct their knowledge about practice. Not only can users move through physical space and time, but it is possible to build and navigate along multiple semantic networks.

Although hypermedia learning systems are a relative newcomer to the arena of educational technology, their effectiveness might be predicted from research on earlier more primitive attempts to integrate video and print materials in ways that were interactive with learners (Bosco, 1986; Hannafin, 1986; Reeves, 1986; Seal-Wanner, 1987). This research is supported by findings about the kinds of materials that support student engagement in and learning from academic work, which suggest that the presentation of cases and other primary source materials, accompanied by flexibly accessed and multiple interpretations are particularly effective (e.g., Five, 1988; Hawkins and Pea, 1987; Scardamalia and Bereiter, 1986). The Intermedia system developed by the Institute for Research in Information and Scholarship at Brown University (Yankelovich et al., 1987) for use in college courses and the interactive video simulations piloted in teacher education workshops at Vanderbilt University (Bransford, Sherwood, Vye, and Rieser, 1986) come closest to the project we are proposing using hypermedia systems to exploit these findings. Research that explores the effects of these systems on learners is currently underway.

Hypermedia Design Problems We Propose to Address

What is *different* about the system we are developing is that it offers the user a vast set of materials that document and annotate the teaching and learning processes in two mathematics classrooms over an entire year. Because the materials are built on a stance toward research on teaching that involves the practitioner in the construction of knowledge about practice (see Lampert, 1985a, 1989a), they are more than illustrations of how to apply research findings to classroom work. Instead of beginning with a theoretical framework for what we want novices to know about teaching and learning, we are beginning with rich qualitative data that represents the complexity of actual incidents of teaching and learning. The use of video, audio, and graphic evidence to support assertions about patterns and possibilities in social interaction is new to researchers (Hawkins and Pea, 1987; Roschelle, Pea, and Trigg, 1990; Suchman and Trigg, in press) and it is certainly new to teacher educators and teacher education students.

The challenge we face is figuring out how to organize the data in ways that make it accessible while retaining its verity. The material we are collecting is both an astounding resource and a formidable challenge. Conventional methods of researching and describing teaching and learning have not been successful in connecting users of the information they produce with the realities of classroom life. We are designing a communications system that addresses this problem. The capacities of a hypermedia system we are examining include the following:

- The possibility of having two sound tracks on a video of a lesson which could be alternately accessed: one recording the natural sound track of the lesson and the other recording the teacher's commentary

- Instant accessibility of portions of the videodisc so that one can compare students' activities at various points in a lesson, relate them to activities in prior or future lessons, and replay them easily and repeatedly for fine-grained analysis

- The capacity to annotate the same lessons using different conceptual frames and to relate incidents in lessons in various ways, to follow one learner through several lessons and track changes in thinking, to follow a teaching strategy and see how it is used differently and has different results in different contexts, to follow a subject matter theme such as "fractions" and examine how this topic is related by teacher and students to problem-solving activities and mathematical tools such as ratio and proportion, percents, division, and so forth

- The possibility of graphic overlays which present alternative representations of the mathematical concepts under discussion, thereby addressing teacher

education students' need for both content and pedagogical knowledge in a context that integrates them in relation to the activities of teaching children

We want to study how instructors who wish to make presentations or stimulate discussion in a teacher preparation course and students who wish to learn about teaching mathematics might exploit these characteristics of hypermedia technology to create an environment that supports inquiry into teaching. An instructor of a mathematics methods course could, for example,

- Show students an example of a mathematics discussion occurring in a third- or fifth-grade classroom
- Analyze the discussion by using a hypercard program that would call up examples from the lesson of how the teacher worked to involve students of different ability levels
- Switch to another stack that would track the development of the subject matter content through the discussion and relate it to instances when that content was addressed in other lessons
- Use yet another stack to follow the participation of a particular child in the discussion and compare his or her thinking about a mathematical topic with the thinking expressed on the same topic at another point in the year

The teacher education students in a course where such a tool was used could do things such as

- Create their own set of annotations on the lesson, perhaps building a stack on a learner other than the one presented by the instructor
- Learn about how a teacher creates teaching in response to children's thinking about a mathematical topic, for example, by searching for instances of particular and common "misconceptions" and consider how the teacher worked in each instance to both respect and develop the student's thinking
- Examine issues of equity and the sorts of decisions teachers face about involving girls in mathematical activity by searching among the lessons for instances where teachers faced this problem and look at both what they did and listen to or read their reflections on why they did it
- Access a set of annotations constructed by a researcher whose specialty is educational sociology and see what he or she would say about the same incidents, enabling them to look at the lesson in terms of social or justice as well as academic goals

We want to learn about whether such activities constitute a more effective pedagogy for teacher education than the one currently in place.

Prospective teachers who use the system we seek to create would be confronted with a concrete image of practice, one that would look quite different from anything they had seen or experienced. And, beyond *seeing* it, they would be able to examine and analyze it, unpacking the considerations that are interwoven in its enactment: the mathematics, the classroom discourse, the students, and the like. Teacher educators who had access to these tools would be able to ground what they are teaching in the practical deliberations of real teaching. We do not propose this tool as the complete curriculum for learning to teach; rather, we see it as one piece of the preparation of new teachers, a piece designed to challenge common ideas about what teachers need to know and how that knowledge is acquired. It is with this goal in mind that we will evaluate the effectiveness of our design ideas.

Project Strategies and Time Line

The work of the project is divided into three major components: the collection of video and other qualitative data to document teaching and learning in our classrooms, editing and development, and piloting and evaluation of the materials' use in teacher education classes.

1. **Data Collection and Cataloging** (1989-90)

Classroom videotaping and collection of support materials. The videotaping in our classrooms is being done by graduate assistants who are trained not only in the technical aspects of taping but also in the concepts of teaching and learning mathematics for understanding that we are seeking to record. Still photographs of children's work and teacher's drawings on the blackboard are being collected and graphics are being prepared to illustrate the mathematical content of lessons. After each taped lesson, we are writing analyses of the lesson that can be used later in annotating the portions of tape for transferral to videodisc and for producing hypercard stacks for use by teacher education students and faculty. The content of the tapes is substantively catalogued by graduate assistants for later reference and the audiotapes are transcribed. In addition, the students in the third- and fifth-grade classes keep notebooks in which they record their mathematical experiments and their reasoning about the problems that make up the agenda of each class; a subset of these students is interviewed on a regular basis to document the lessons from the learners' perspective.

The multimedia information we are collecting is being stored and catalogued using a variety of computer hardware and software. We are designing multiple systems to enable

the location and linking of pieces of information in different formats and experimenting with their practicality.

2. **Editing and Development** (1990-91)

Lesson analysis, annotation, and editing. We are currently experimenting with ways to guide users through the multimedia qualitative data on teaching and learning that we are gathering. Project members are pursuing different paths through the materials and trying out alternative configurations of tape, students' work, records of student interviews, and portions of teacher interviews and written reflections. We are also calling upon three different kinds of collaborators to view tapes and comment on lessons: mathematicians, teacher collaborators, and teacher educators who are also researchers on teaching. We are beginning now to hold these annotation sessions, starting with a few colleagues in different education fields and three mathematicians. Their comments are audiotaped and transcribed.

We are also experimenting with preparing a second audio track for the portions of lessons to be transferred to videodisc on which we will record a verbal commentary on the teaching strategies and decisions portrayed there.

Production of hypercard stacks. Using the videodiscs and CD ROM discs, transcripts of lessons and analyses, and other materials, hypercard stacks will be prepared which map out several paths through the data. We have major content design responsibilities for this task, assisted by programmers who carry out the technical design work. As we assemble these different resources, we will begin to experiment with the use of the materials in a few teacher education courses. These experiments will help to inform the ongoing development--configuration, annotation, access--of the materials.

3. **Piloting** (1991-92)

Use of materials in teacher education courses at MSU. Although we are conducting formative research by involving teacher education students in reviewing the materials at every stage in the process, teacher education faculty at Michigan State University will begin to try out the materials more systematically during the Spring of 1991 and continue to work with them during 1991-92; their experiences will inform the development of supplementary materials for use by teacher educators in other settings.

Dissemination of materials to the broader teacher education community. During Fall and Winter 1992, we will pilot these materials in a variety of teacher education settings. Settings may include introductory education courses; courses on learners and learning (educational psychology); social foundations courses focused on the purposes of schooling as well as those that emphasize cultural diversity in classrooms; a mathematics course; and several different courses on the methods and materials of teaching mathematics. During the Summer of 1992, we will hold a two-day workshop for selected teacher educators. MSU

faculty who have already tried the materials will collaborate in planning and conducting this workshop. At this workshop, participants will have the opportunity to look at and discuss the materials, as well as to plan with other faculty ways in which they might use them in their particular courses. This workshop will be documented, so as to produce a record of issues that surfaced in teacher educators' deliberations about using the materials as pedagogical tools.

Documentation and evaluation of pilot use of materials. During Years 2 and 3 of the project, we will document the uses of the materials at MSU and elsewhere, observing in classes and interviewing faculty members about what they are trying to accomplish with the materials. We will also document how students work with the materials and what kinds of things they learn. For this purpose, we will draw on instruments developed by Ball and her colleagues at the National Center for Research on Teacher Education (Ball and McDiarmid, 1988). Continued editing and development of the materials will be informed by what we are learning from these pilots in teacher education settings.

Project Impact

The project has the potential to make a substantial contribution to current efforts to increase the impact of preservice mathematics teacher education as well as to current discourse about teachers' knowledge use in practice. The goal of the project is to produce materials for use in elementary mathematics teacher preparation, materials that can highlight the interaction among essential components of good practice. These materials will be developed so that they will be useful in a variety of teacher education settings--that is, different kinds of courses or experiences as well as different institutions.

But beyond the teacher education materials we will produce, the project represents a foray into a new terrain for exploring teaching, experimenting with the potential of new hypermedia technologies as intellectual springboards and playgrounds for analyzing and creating good practice. Our efforts have the potential to affect both the teacher education community and the world of technology and education systems developers, additionally serving to forge new connections between these two communities. We are seeking to produce a vivid picture of what it means to teach and learn mathematics in classrooms--a picture we believe to be more veracious and powerful than traditional researchers' accounts of these activities. And we are proposing to use this representation of the activities of teaching and learning to initiate novices into the profession. The technologies that are now available (and those that may become available in the next few years) make us believe that this vision can be realized in a way that it could not be with simple print materials or direct observations of exemplary teaching.

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